1,149,022

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,149,022

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Int. Cl.:—H 01 j 61/34

COMPLETE SPECIFICATION

High-Pressure Electric Discharge Lamps

We, SYLVANIA ELECTRIC PRODUCTS INC., a Corporation organised and existing under the laws of the State of Delaware, located at 100 W. 10th Street, Wilmington, Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to high-pressure electric discharge lamps and particularly to those lamps which have a filling in the arc tube which includes mercury, a halogen and sodium.

In the past few years, research has been conducted to change the emission colour of high-pressure electric discharge lamps. Prior art lamps contained mercury vapour exclusively, and the discharge produced by them was the typical mercury discharge consisting of discrete, separate wave-lengths, generally called lines. Almost all of the radiation of those lamps was contained in the blue region, together with a line in the green and two lines in the yellow. Hence, when the high-pressure mercury discharge lamps of the prior art illuminated a red object, particularly one reflecting light only in the range of 6000 to 6800Å, the object appeared black.

Attempts have been made by the art to obviate this problem and among the suggested modifications has been to include in the mercury arc stream, various metallic elements which emit radiation at wave-lengths different from mercury emission. Thus, lamps having such inclusions would produce radiations resulting from a combination of mercury lines together with lines of the metallic additions. For example, thallium, zinc, cadmium, or sodium metals have been added to the arc stream. Although these additions did add other lines to the spectrum and improve the colour rendition of the lamp, still only a series of separate and discrete lines were generally present. A light source derived from a large number of lines was yet to be obtained from them.

The art then discovered that phosphors could be placed on the inner surface of the lamp envelope so that some of the ultra-violet radiation of the device could be converted into visible light, particularly in the red, if that phosphor was used. Then the blue emission of the mercury discharge was supplemented with the reddish emission of the phosphor and a reasonable white light was produced by the lamp. But this did not fully solve all of the problems of the device since the core of the problem lay in the failure of the mercury discharge to produce balanced light by itself. Moreover, phosphor coatings tended to produce a loss in efficiency of the lamp because the phosphor absorbed some of the visible radiation from the mercury discharge.

It was then found that the emission colour of the arc stream could be changed by adding halogens, particularly iodine, together with light-emitting metals whose halides have high vapour pressures and a multiplicity of emission lines in the visible spectrum. Unfortunately, the operating voltages of these devices tended to be rather high and they could not be installed in existing lamp installations as replacements. It was then discovered that if sodium atoms were added to the arc tube, that the operating voltages could be reduced. However, this addition tended to prove troublesome because it was discovered that the sodium ions migrated out of the arc tube during lamp operation. They migrated right through the quartz envelope and into the outer jacket of the lamp. Thus when the sodium ions migrated from the arc tube, they were not available to continue their work preventing a high operating voltage. Operating lamp voltage is an inverse function of the sodium content of the discharge.

It has now been discoverd that the con-

struction of the lamp harness, particularly the side rods of the metallic supporting assembly of the arc tube, such as shown in the U.S.A. patent to Gustin No. 3,094,610 tends to increase the rate of sodium migration from the arc tube. These rods are generally situated within approximately 2 centrimetres of the arc tube wall and carry current from the outer end of the arc tube back to the base of the lamp. Since these side rods are electrically connected to one electrode of the arc tube, a potential exists between them and the inner surface of the arc tube. Measurement using 1000-watt lamps has shown that a d.c. potential of approximately 100 volts exists, of such a polarity that the inside surface of the quartz is negative with respect to the side rods. Thus any positive ions present in the quartz will have a force exerted upon them forcing them outward through the quartz. When positive ions of alkali metal, particularly sodium, are used in the arc tube, migration through the quartz wall occurs due to this force. When these ions arrive at the outside surface, they are neutralised by photo-electrons emitted from the side rods. If it were not for the neutralization of these positive ions by photo-electrons from the side rods, the accumulation of positive charge on the outside surface of the quartz due to the arriving ions would repel positive ions and prevent the subsequent migration of any more sodium ions through the quartz. Thus the completion of the d.c. electric circuit by photo-electrons emitted from the side rods is a major factor in the rapid electrolytic loss of sodium metal from the arc tube. Further, the sodium atoms which result from neutralised sodium ions immediately evaporate due to their high vapor pressure, since the temperature of the outer wall of the arc tube is approximately 800°C. They then deposit on the relatively cool outer bulbous envelope as a coating.

Measurements using radioactive sodium as a "tracer" have shown that with conventional construction a loss of approximately 1.0 mg. of sodium metal results in one thousand hours. When the side rods are moved to within $\frac{1}{16}''$ of the wall of the quartz envelope, the loss rate is approximately 2.0 mg. per thousand hours. Moreover, the distribution of sodium within the quartz itself shows pronounced maxima in the outside surface opposite the locations of the side rods, indicating that electric forces are attracting the positive sodium ions to these areas of the outside surface.

When the side rods of the arc tube harness are eliminated, part of the circuit will be broken; that is, a major course of electrons to recombine with sodium ions is eliminated. Any current now flowing will, of necessity, occur between the leads of either end of the arc tube and the arc tube walls. In addition, when the arc tube harness is constructed in the manner as set forth, arcing between conducting members having opposite polarity is substantially eliminated. A detailed discussion of the problem is stated in the U.S.A. Patent No. 3,222,556.

Accordingly, the primary object of the invention is a reduction of the electrolytic migration of sodium through the quartz walls of an arc tube in a high pressure discharge lamp in order to achieve stabilisation of the operating voltage.

In accordance with the invention there is provided a high pressure electric discharge lamp comprising an arc tube having a fill including mercury, halogen, and sodium atoms, an outer jacket surrounding the arc tube and having leads for the supply of current to the arc tube entering through one end of the jacket, a conductor for conveying current to the other end of the arc tube and independent supports for supporting each end of the arc tube from the respective end of the jacket, the support at the end remote from the entry of the current leads being secured to the end of the arc tube and engaging the inner surfacc of the jacket to locate the end of the arc tube relative to the jacket, and the said conductor being arranged remote from the arc tube to minimise its influence on the passage of sodium atoms through the arc tube wall during operation.

The invention will be described in more detail with reference to the accompanying drawings wherein specific embodiments of our invention are shown and described by way of illustrative examples.

Of these drawings:

Fig. 1 is an elevational view, partly in cross-section, of one embodiment of the high-pressure electric discharge device according to the invention.

Fig. 2 is a cross-sectional view, partly in cross-section, of another embodiment of the high-pressure electric discharge device according to the invention.

Referring now to Fig. 1 of the drawings, the lamp includes a generally tubular outer bulbous envelope 1 having a bulbous central portion and a conventional base 14 attached to the bottom thereof. Extending inwardly from the base and inside of the envelope 1 is a mount 15 having a pair of stiff lead-in wires 12 and 16 in electrical conducting relation with the base 14. Disposed upon one of the stiff lead-in wires 12 is a lower, U-shaped support 8 welded thereto. The U-shaped support 8 comprises a pair of vertical wires 23 and 24 rising from a horizontal base 14 wire 25. The upper ends of the lower U-shaped support 8 are welded together with a lower strap 7 which in turn supports an arc tube 2. Preferably, the lower strap includes two sections abutting against either side of the arc tube 2 thereby holding it firmly in place. They touch only the press seal of the arc

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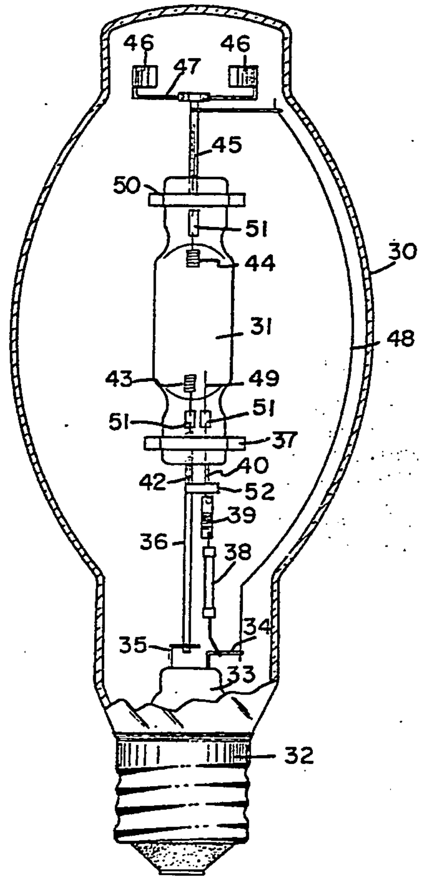

FIG. 2

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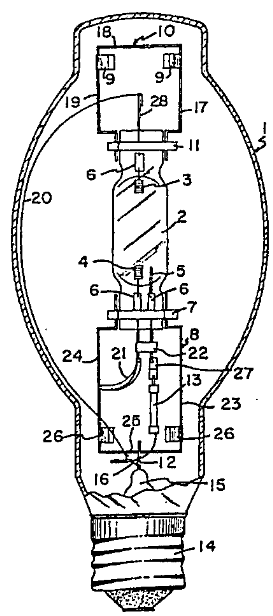

FIG.1

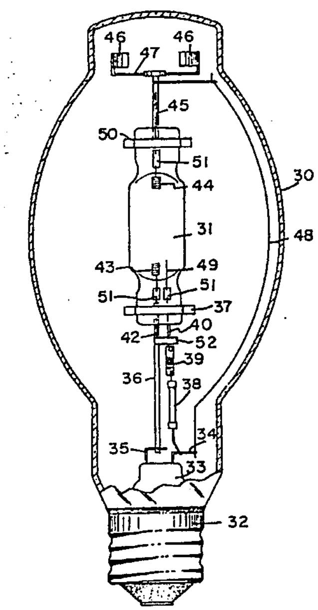

FIG.2

tube and not the body. Generally, both sides of the lower strap 7 can be of identical construction. A pair of bumpers 26 are welded to the lower U-shaped support 8 and abut against the tubular portion of walls of the outer bulbous envelope 1 thereby stabilising the structure within the lamp. Preferably, these bumpers are made of a resilient material so that if the lamp is jarred they will absorb much of the shock.

Since the lower U-shaped support 8 is electrically connected to the stiff lead-in wire 12, the support 8 forms part of the circuit in the device. Current passes from the base 14 into the lower U-shaped support 8 and thence to lead-in wire 21 which in turn is connected to a cathode 4 in the arc tube. It is sometimes desirable to place an insulating shield about the lead-in wire 21 to prevent arcing within the lamp and between the various elements. Current passes from the lead-in wire 21 to the cathode 4 through an intermediary molybdenum foil section 6.

The other side of the circuit is formed through the stiff lead-in wire 16 which is preferably bent out of place so that parts on one side of the line are insulated from those on the other side. A resistor 13 is attached to the stiff lead-in wire 16 through a lead-in wire associated therewith and thence to a connector 27 which in turn leads through a molybdenum foil section 6 to the starting probe 5. A bi-metal 22 is disposed between lead-in 21 attached to the cathode 4 and the lead-in wire 27 which is attached to the starting probe 5. The bi-metal 22 is biassed open when the lamp is turned off but when the lamp starts, it biasses closed against the lead-in wires to the probe 5 thereby establishing the same current potential at the probe 5 and the cathode 4. Such closing prevents electrolysis between the probe and the cathode.

At the other end of the arc tube 2, an upper support 10 is mounted within the tubular portion of bulbous envelope 1. The support frame 10 includes a horizontal section 18 having vertical supports 17 and 19 depending downwardly therefrom and attached at the free ends to an upper strap 11 which surrounds the press seal of arc tube 2 and rigidly holds it in place. Preferably, the construction and disposition of the upper strap 11 is similar to lower strap 7. A pair of upper bumpers 9 are mounted upon the vertical sections 17 and 19 of the upper support 10 and resiliently abut against the sides of the tubular portion of the bulbous envelope 1. Such disposition prevents breakage of the lamp if the arc tube is shaken or dropped.

A lead-in wire 28 extends to the outside of the arc tube 2 and is attached at its inner end to a molybdenum foil section 6 and thence to a cathode 3. An electrical connection is made between stiff lead-in wire 16 and lead-in wire 28 through a thin conducting lead 20 which may be of any suitable conducting material. Preferably, the conducting lead 20 is as distantly removed from the arc tube 2 as possible, generally by bending it around the perimeter of the outer bulbous envelope 1.

Referring now to Fig. 2 of the drawings, a tubular envelope with a central bulbous portion 30 similar to that shown in Fig. 2 has a base 32 disposed at the bottom thereof and including a mount 33. Extending through the mount 33 is a pair of stiff lead-in wires 34 and 35 which can be appropriately bent if desired to attain insulation. Extending upwardly from one of the lead-in wires 35 is a lower support 36 which is attached by welding to strap 37 which surrounds the base of the arc tube 31 and holds it firmly in place. Lead-in wire 42 is welded to lower support 36 so as to establish an electrical connection. Cathode 43 is electrically connected to lead-in wire 42 through molybdenum foil section 51. A resistor 38 is attached to stiff lead-in wire 34 and thence through electrical connector 39 to lead-in wire 40 and to probe 49 through molybdenum foil section 52 which extends through the press seal of the arc tube 31. A bi-metal 52 is placed across the rod 36 and the lead-in wire 40 and performs the same function as bi-metal 22 shown in Fig. 1.

At the other end of the arc tube, an upper strap 50 extends around the press seal of the arc tube 31 and is welded in electrical conducting relationship with upper support 45. Generally, the support straps 37 and 50 are strips of metal, stretched tightly across the press seal of the arc tube 31 to hold it rigidly in place. A brace 47 is attached to the top of upper support 45 and a pair of bumpers 46 abut resiliently against the sides of the tubular portion of the outer bulbous envelope 30.

Electrically, cathode 44 within the arc tube 31 is attached through molybdenum foil 51 to lead-in wire 45 and thence in turn to conducting lead 48 and finally to stiff lead-in wire 34 to complete the circuit.

Similarly, as with the conducting lead described in Fig. 1, the conducting lead 48 extends as distantly as possible from the arc tube 31 and is near the periphery of the bulbous envelope 30. Of course, extending the wire distantly from the arc tube 31 can be modified, if desired, particularly in cases where the migration of sodium described heretofore is not too acute. For example, it may be stretched downwardly from some suitable location on the upper support 45 to the stiff lead-in wire 34.

When lamps were made in accordance with the principles of this invention, instead of a loss rate of 1.0 mg. of sodium metal per one thousand hours, a loss rate of 0.24 mg. per thousand hours resulted. In addition, there was a pronounced difference in the distribution of sodium in the outside surface of the quartz envelope of the arc tube. Table I below shows

the distribution of sodium in the outside surface of the arc tube in two different lamps, one mounted in a harness with side rods $\frac{1}{16}$" away from the arc tube wall, the other without. The quartz arc tubes were section into eight circumferential sections, of which section (I) was at the top of the horizontally-operating arc tubes, section (5) was at the bottom and (3) and (7) were midway at the sides. In lamp 1, with side rods, the side rods were in the horizontal plane, opposite sections (3) and (7).

TABLE I

Sodium Concentration (parts per million)
In the Outside Surface of the Quartz

	Lamp 1 (with side rods) sodium loss rate 2.0 mg./1000 hrs.		Lamp 2 (with no side rods) sodium loss rate 0.24 mg./1000 hrs.
Section 1 (top)	1.62 ppm		4.6 ppm
Section 2	10.3 ppm		6.2 ppm
Section 3 *	40.9 ppm		11.3 ppm
Section 4	11.2 ppm		14.4 ppm
Section 5 (bottom)	17.7 ppm	(bottom)	17.7 ppm
Section 6	11.5 ppm		13.6 ppm
Section 7 *	33.8 ppm		7.5 ppm
Section 8	8.3 ppm		3.1 ppm

*opposite side rods (Lamp No. 1).

In both lamps the sodium which had been lost from the arc tube upon ageing was quantitatively accounted for inside the outer bulbous envelope.

Notice that the major difference in the concentrations of sodium in the outside surface of these two arc tubes, which differed by a factor of about ten in the sodium loss rates, is in the sections opposite the side rods in lamp number 1. It is plain that neutralisation of sodium ions in these sections by photo-electrons emitted from the side rods has resulted in greatly increased flow of sodium through the quartz to the outside surface, and is the cause of the major difference in sodium loss rates.

WHAT WE CLAIM IS:—

1. A high-pressure electric discharge lamp comprising an arc tube having a fill including mercury, halogen, and sodium atoms, an outer jacket surrounding the arc tube and having leads for the supply of current to the arc tube entering through one end of the jacket, a conductor for conveying current to the other end of the arc tube and independent supports for supporting each end of the arc tube from the respective end of the jacket, the support at the end remote from the entry of the current leads being secured to the end of the arc tube and engaging the inner surface of the jacket to locate the end of the arc tube relative to the jacket, and the said conductor being arranged remote from the arc tube to minimise its influence on the passage of sodium atoms through the arc tube wall during operation.

2. A lamp as claimed in claim 1 in which the said conductor is a wire arranged close to the inner surface of the jacket.

3. A lamp as claimed in claim 1 or 2, in which the support for the end of the arc tube nearest the entry of the current leads is attached to one of the current leads.

4. A lamp as claimed in any of the preceding claims in which the support for the end of the arc tube remote from the entry of the current leads has a pair of resilient bumpers which engage the inner surface of the jacket.

5. A lamp as claimed in any of the preceding claims, in which the support for the end of the arc tube nearest the entry of the current leads has a pair of resilient bumpers which engage the inner surface of the jacket.

6. A lamp as claimed in any of the preceding claims in which the support for each end of the arc tube includes a strap embracing the end of the tube.

7. A lamp as claimed in claim 6 in which

each support includes a rod extending axially within the jacket and attached at one end to the strap.

8. A lamp as claimed in claim 6 in which each support includes a generaly U-shaped wire whose free ends are attached to opposite ends of the strap.

9. A lamp as claimed in any of the preceding claims wherein the arc-tube fill includes a light-emitting metal whose halide has a high vapour pressure and a multiplicity of emission lines in the visible spectrum.

10. A high-pressure lamp substantially as described with reference to Fig. 1 or Fig. 2 of the accompanying drawings.

REDDIE & GROSE,
Agents for the Applicants,
6, Bream's Buildings,
London, E.C.4.

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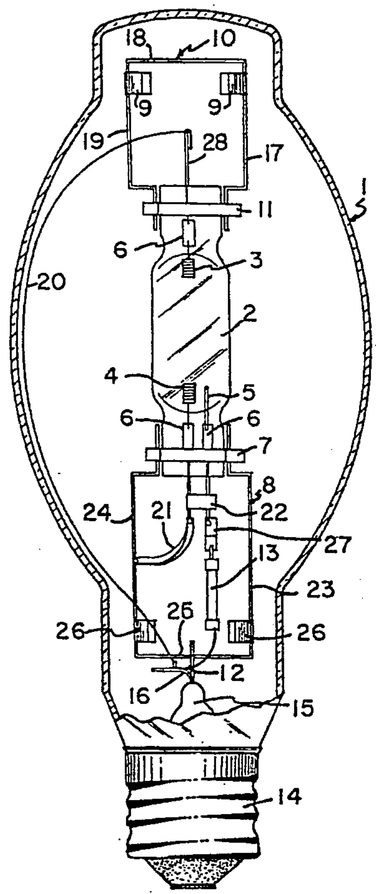
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FIG. I